FLORISTIC COMPOSITION AND STRUCTURAL ANALYSIS OF WOODY VEGETATION IN DIRKI AND JATO FORESTS, WEST SHEWA ZONE OF OROMIA REGION, ETHIOPIA

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As thesis advisor, I herby certify that I have read and evaluated this Thesis entitled "Floristic Composition and Stractural Analysis of Vegetation in Ilu Gelan District, West Shewa Zone of Oromia Region Central Ethiopia" prepared under my guidance by Kasahun Dechasa. I recommend that it be submitted as fulfilling the thesis requirement.

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DEDICATION

I dedicate this thesis manuscript to my parents for their love, affection and unrestricted encouragement they offered me not only in accomplishing this research, but also for every success in my life.

STATEMENT OF THE AUTHOR

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BIOGRAPHICAL SKETCH

The author was born in August, 1978 in Hababo Guduru, Horo Guduru Wollega, Oromia Regional State. He attended his elementary and junior education at Himbabo Elementary School, Hababo Guduru District. Then he pursued secondary school education at Shambu Secondary School. In1997, he joined Jimma Teachers College and received his diploma. Then, after he worked as a teacher for five years at Daleti Elementary and Deressa Wayessa secondary schools, he joined Haramaya University in 2005 and received his Bachelor of Education (BEd) degree in Biology in summer program. Then, he worked as a teacher at Gedo Secondary and Preparatory School for four years until he joined Haramaya University for his graduate study program in biology in 2013.

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ACRONMYS/ABBREVIATIONS

BA	Basal Area
CSA	Central Statistical Agency
DBH	Diameter at Breast Height
EFAP	Ethiopian Forestry Action Plan
EPA	Environmental Protection Agency
FAO	Food and Agricultural Organization
GPS	Geographical Positioning System
IBC	Institute of Biodiversity Conservation
IUCN	International Union for the Conservation of Nature and Natural Resources
IVI	Importance Value Index
LC	Least Concerned
MoA	Ministry of Agriculture
NBSAP	National Biodiversity Strategy and Action Plan
NT	Nearly Threatened
RBA	Relative Basal Area
RD	Relative Density
Rdo	Relative Dominance
RF	Relative Frequency
SCBD	Secretariat of the Convention on Biological Diversity
SIV	Species Importance Value

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Floristic Composition and Structural Analysis of Woody Vegetation in Dirki and Jato Forests, West Shewa Zone of Oromia Region, Central Ethopia

ABSTRACT

This study was conducted on Dirki-Jato vegetation in Ilu Gelan District, West Shewa Zone of Oromia Region to identify floristic composition and analyze species dominance and diversity in the vegetation. Vegetation data were collected from 54 quadrats of 20 m x 20 m (400 m^2) laid systematically along transects. In each quadrat, live woody species were recoded with their local names and scientific names (where possible), numbers counted and DBH measured for those with DBH>2cm. Sample specimens were collected for each species and identified in Haramay University Herbarium using literatures and experts. Quantitative vegetation data such as Shannon-Weiner diversity index, eveness, density, basal area, relative density, relative frequency, relative dominance and importance value index were computed. Sorensens's similarity index was also computed to compare similarities in family, genera and species with other similar vegetations studied in different parts of the country. Results showed that a total of 106 woody plant species distributed within 84 genera and 49 families were identified. Fabaceae, Rubiaceae, Euphorbiaceae, Combertaceae and Moraceae were the most diverse families with 14, 6, 6, 6 and 6 species, respectively. Overall average Shannon-Wiener diversity index (H`) was 3.23 and the average evenness values (E') was 0.69 indicating high diversity with more or less even distribution of species. Seven endemic species were recorded from the study area of which three were near threatened. Total density and basal area calculated for woody species were 10202.37 individuals' ha^{-1} and 45.87 m^2 ha^{-1}, respectively. The densest species in the study area were Maytenus *gracilipes, Maytenus arbutifolia and Celtis africana while the dominant species were Cordia Africana, Ficus sycomorus and Ficus vasta. Species with the highest IVI were Cordia africana, Maytenus arbutifolia and Maytenus gracilipes. In spite of its diverse nature, human are interfering with this natural vegetation that needs awarness rising of the locals to maintain the vegetation.*

Key words/phrases: Shannon-Wiener diversity, species diversity, species dominance,
Dirki-Jato vegetation, Importance value index, Equitability index, Sorensen's similarity index.

1. INTRODUCTION

Worldwide forests are known to be critically important habitats in terms of the biological diversity they contain and in terms of the ecological functions they serve (SCBD, 2001). Ecologically, forest gives important environmental benefits by providing carbon sink/ carbon storage service, watershed protection services (protects soil erosion and flooding) and providing habitats for a large number of animals (SCBD, 2001; Nune *et al*., 2010). Also, the forest serves as a source of food, household energy, construction and agricultural material, tourism and recreation values and medicines for both people and livestock (Bekele, 1994; Vivero *et al*., 2005).

Converting natural landscapes for human use on human-dominated lands have transformed a large proportion of the earth's surface (Foley *et al*., 2005). Human actions are changing the world's landscapes in persistent ways. Clearing of forests, intensification of farmland productivity and expansion of urban centers are the most practiced land-use changes threatening tropical forests (Defries *et al*., 2004). Even though the practices of land-use change vary greatly throughout the world, the ultimate goal is always the acquisition of natural resources for immediate human needs usually at the expense of environmental degradation (Foley *et al*., 2005).

Ethiopia is a country found in the horn of Africa between the geographical coordinates of 3^{o} 24' and 14^{o}53' North and 32^{o} 42' and 48^{o} 12' East. According to Ministry of Agriculture; (MOA) (2000), the total area of the land of the country is 1.12 million km^{2}. The country has different topographic land features such as mountains, deep gorges, low lands, valleys and flattened plateaus (Zerihun Woldu, 1999). These different topographic features assisted different types of flora and fauna that have been well adapted to their own geographical features and climatic conditions. According to Fayera Senbeta *et al.* (2007), the climate and topography of Ethiopia vary considerably and appear to have effects on the distribution of biological diversities. Thus, Ethiopia is considered as a country having high biodiversity in Horn of Africa (NBSAP, 2005).

Large part of Ethiopia was believed to have been covered by forests and woodland vegetations in the past (Friis, 1992). However, due to continuous massive deforestation made on it, the vegetation cover has been reduced through time to what it looks like at the present (Yitebitu Moges *et al.,* 2010). Different researchers have studied the vegetation of Ethiopia at different times (White, 1983;Friis, 1992; Demel Teketay, 1992; Tamrat Bekele, 1994; Abate Ayalew, 2003; Tesfaye Awas *et al*., 2001; Fayera Senbeta, 2006; 2007; Motuma Didita, 2007; Haile Adamu, 2012; Abyot Dibaba *et al*., 2014). The results of these studies could broadly categorizethe vegetations of Ethiopia into nine major types. These include: Afroalpine and Subafroalpine Vegetation, Dry Evergreen Montane Vegetation, Moist Evergreen Montane Forest, Evergreen Scrub, *Combretum-Terminalia* (broad-leaved deciduous) woodland, *Acacia-Commiphora* (Small-leaved deciduous) woodland, Wetlands, Lowland Dry forest, and Desert and semi-Desert scrub. Out of the nine vegetation types, four of them occur in the dryland regions. These include: *Combretum-Terminalia* (Broad-leaved deciduous woodland), *Acacia-Commiphora* (Small-leaved deciduous woodland), Desert and semi-desert scrub land and Dry Evergreen Montane Vegetation.

The coverage of each of the vegetation category has been declining rapidly due to the anthropogenic impacts such as demand of land use for expansion of agriculture by local farmers, overgrazing, illegal exploitation of forests and forest products (Friis, 1992; Feyera Senbeta and Fekadu Tefera, 2001). Extensive agricultural investment and expansion of road construction through vegetation are also becoming other causes of deforestation. Currently, increasing rate of drought, desertification and shortage of food for both humans and animals are becoming serious problems that need attentions (Yitebitu Moges *et al*., 2010). These problems are directly related with the pressures exerted on vegetation by human beings, and thus need immediate solutions. Therefore, it is very important to study the current status of our vegetation to identify the problems and threats associated with them and make useful recommendations that are helpful for planning their future conservation and sustainable management. Althoguh there have been some researches on dry evergreen afro montane vegetations of the country in different corners, no floristic study was conducted on the woody vegetation of Dirki and Jato forests. Therefore, this study was intended to generate basic scientific information on the floristic composition and structures, and species dominance of the woody vegetation found in Dirki and Jato forests with the following general and specific objectives.

General Objective:

The general objective of this study was to assess the floristic composition, structure and species dominance of woody vegetation of Dirki and Jaro forests, West Shewa Zone.

The specific objectives of the study were:

- To identify the species composition of the vegetation of the study area
- To identify the structure of woody vegetation in the study area
- To characterize the dominant woody plant species of the study area.

2. LITERATURE REVIEW

2.1 Vegetation

According to van der Maarel (1979), vegetation is defined as a system of spontaneously growing plants in a particular region. However, cultivated plants such as crops and weeds surrounding them are not considered as vegetation. Some experts define vegetation as a concrete stand of plants occurring in a uniform environment with relatively uniform floristic composition and structure (van der Maarel, 1979). The composition and structure makes it distinct from the surrounding environment (van der Maarel, 1979). In contrast to this, other experts explain it as an abstract nature characterized from all other relevant features of that vegetation (van der Maarel, 1979).

Vegetation is considered from plant community perspective as the sum total of its parts and this idea guided plant ecologists to develop the concepts of dominance and diversity in the study of vegetation ecology (van der Maaler, 1979). Vegetation characteristics are either derived from plant morphological characters, usually called structure, or from the plant species recognized, the floristic composition.

As stated by Grossman *et al* (1998), vegetation is dynamic, and often requires a high degree of variability. It is also measured for both inventory and monitoring purposes, and can be used as a strong indicator of the ecological functioning. Thus, classification of vegetation can serve as an important component of a larger strategy to understand and conserve this natural resource.

2.2 Vegetation Type of Ethiopia

Ethiopia is regarded as one of the most important countries in Africa with respect to endemism of plant and animal species (EFAP, 1994). The vegetation type of Ethiopia is considered extremely complex, where the complexity is due to the great variations in altitude. The difference in altitude in turn results in great variations of spatial distribution of vegetation in the country (Zerihun Woldu, 1999).

Different researchers have studied the vegetation of Ethiopia at different times (Demel Teketay, 1992; Tamrat Bekele, 1994; Abate Ayalew, 2003; Fayera Senbeta, 2006; 2007; Motuma Didita, 2007; Sisay Nune, 2008; Haile Adamu *et al*., 2012; Abyot Dibaba *et al*., 2014). Some scholars have classified the vegetation of Ethiopia into eight categories, whereas others classify into nine as:

- Afroalpne and Subafroalpine Vegetation,
- Dry Evergreen Montane Vegetation,
- Moist Evergreen Montane Forest,
- Evergreen Scrub,
- *Combretum-Terminalia* (Broad-leaved deciduous) woodland,
- *Acacia-Commmiphora* (Small-leaved deciduous) woodland,
- Wetlands,
- Lowland Dry forest, and
- Desert and semi-Desert scrub.

Dry evergreen montane forest and grassland complex: this type is characterized by trees of various sizes and extensive grasslands that are rich in legumes. Common tree species include *Juniperus procera, Olea europaea, Celtis africana, Euphorbia ampliphylla, Mimusops kummel* and *Ekebergia capensis.* Typical shrubs include *Dracaena spp., Carissa edulis,and Rosa abyssinica*, while common grass species belong to the genera Hyparrhenia, Eragrostis, Panicum, sporobolus, Eleusine and Pennisetum, and the legumes include Trifolium ,Eriosema and Crotalaria species.The forest grasslad ecotone is occupied by Acacia woodland with abyssinica*, A.negri and A.pilispina* the commonest trees.

Desert and semi-desert scrubland: characterized by highly drought-tolerant woody plants such as *Acacia spp*., succulent species of *Euphorbia* and *Aloe*, and grasses including *Dactyloctenium aegyptium* and *Panicum turgidum.*

Small-leaved, deciduous woodland of *Acacia–Commiphora*: The altitudinal range in which the ecosystem is found is 900-1900 meters above sea level. Drought-tolerant tree species and shrubs, with either small deciduous leaves or leathery, persistent ones characterize this vegetation-type and typical species include *Acacia tortilis*, *A. mellifera* and *Balanites aegyptiaca* together with various species of *Commiphora, Capparis, Combretum* and *Terminalia*. The ground Layer includes the herbs *Acalyph* and *Barleria spp.*

Broadleaved, deciduous woodland of Combretum–Terminalia and Savannah: tree species in these woodlands are small in size with fairly large deciduous leaves and an understorey of herbs and grasses. The dominant trees and shrubs are *Combretum* and *Terminalia spp*., *Boswellia papyrifera, Lannea schimperi and Anogeissus leiocarpu.*

Riparian and swamp vegetation: typical tree species include *Celtis africana, Ficus sycamorus, Mimusops kummel, Tamarindus indica, Maytenus senegalensis, Acacia spp., Kigelia aethiopium* and Syzygium guineense. Swamps are dominated by sedges (especially species of Eleocharis and Scirpus), grasses (particularly Echinochloa spp.) and many herbs.

Moist evergreen Montane Rainforest: The montane moist forest ecosystem comprises high forests of the country mainly the southwest forests, which are the wettest, and also the humid forest on the southeastern plateau known as the Harenna forest. The montane moist forest ecosystem is distinguished by supporting luxuriant growing epiphytes *Canarina, Orchids, Scadoxus* and fern plants such as *Platycerium* and *Drynaria*. Mosses also occur in the wettest part of forests associated to major branches and barks of trees.

Lowland semi-evergreen forest: characterized by a range of mainly semi-deciduous tree and shrub species. Woody species include the emergent trees *Celtis toka, Diospyros abyssinica, Malacantha alnifolia* and *Zanha golugensis*, while shrubby species include *Alchomea laxiflora, Oncoba spinosa and Whitefield iaelongata.*

Afro-alpine and sub-Afro-alpine vegetation: The areas which on the average higher than 3200 meters above sea level. This vegetation type is characterized by small trees, shrubs and shrubby herbs at lower altitudes and, at higher altitudes, herbs and tuussock-forming grasses. Typical tree and shrub species include *Erica arborea, E. trimera* and *Hypericum revolutum*. Among herbs in this zone are the *giant lobelia Lobelia rhynchopetalum, Kniphofia foliosa,* *Bartsia petitiana* and various *Alchemilla* species. *Festuca, Poa* and *Agrostis spp*. are typical grasses.

2.3. Plant Biodiversity and its Threat in Ethiopia

Ethiopia has a rich biodiversity in both domesticated and wild plant and animal species that occur in variable and unique ecosystems. Even though most of them are common with other countries of the world, some are endemic to the country (FAO, 1996; NBSAP, 2005, EPA, 2012). However, loss of biodiversity due to environmental degradation and continuous deforestation on most vegetation ecosystems is the serious environmental problem Ethiopia is facing at the present (FAO, 1996; NBSAP, 2005). This loss in biological diversity ultimately implies economic losses to the country and the world as a whole (Yitebitu Moges *et al*., 2010). According to Nebiyu Abesha (2009), loss of biodiversity caused as a result of deforestation is a serious problem in Ethiopia. The continued vegetation degradation can cause more and more loss of biodiversity unless management measures are designed and implemented (Million Bekele, 2011). Thus, clearing natural vegetation for agriculture is the most significant threat to ecosystem biodiversities.

In addition to the deforestation caused by understandable needs, negligence as well as the destruction such as by fire, do contribute to deforestation. These types of deforestation have become increasingly frequent in the last 20 years or so. According to EFAP (1994), vegetation resources, particularly forests, are disappearing at a very alarming rate in Ethiopia before we even have a chance to study and document them. If this trend of deforestation continues there may be a great danger of serious decline or loss of biodiversity. Most of the deforestation occurred during the period in which security of land tenure and access to natural resources were undermined by unpopular policy measures such as frequent redistribution of land and restrictions in cutting and utilizing trees, even in one's own backyard. Serious destruction of forests has occurred between the fall of the previous government and the stabilization of the present one (EPA, 1998). *Combretum-Terminalia* woodland is perhaps the least affected of the vegetation categories. However there are threats as a result of indiscriminate fire and settlement of refugees from our neighboring countries and people from the highlands and inappropriate agricultural practice in the country.

Recently, the depletion of vegetation resources and environmental degradation has become issues of national and global concern (Motuma Didita, 2007). This is due to the fact that the declining of vegetation cover and depletion of natural resources are closely associated with the drought and food shortage problems that are becoming great threat to the peoples of the world. Lack of protective vegetation policy is enablingrapid deforestation activity especially in countries like Ethiopia (Haile Adamu *et al*., 2012).

2.4. Plant Community Types

Plant communities are conceived as types of vegetation recognized by their floristic composition. The species compositions of the communities better express their relationships to one another and environment than any other characteristics (Kent and Cooker, 1992). It can be defined as the collection of plant species growing together in a particular location that show a definite association or affinity with each other (Kent and Cooker, 1992). Plant community type is part of the vegetation which shows certain remarkable features that identifies it from its surroundings (van der Maaler, 1979). Different plant community types found within particular vegetationhave relatively their own uniform physiognomical appearance. According to Mueller, Dombois and Ellenberg (1974), a plant community can be understood as a combination of plants that are dependent on their environment and influence one another, and then can gradually modify their environment. However, the performance of the individual plant species, species numbers, plant characters (traits) and species abundance can play crucial roles to determine important characteristics of the plant community.

2.5. Plant Species Diversity, Species Richness and Evenness

Diversity has both an aspect of species richness, i.e. the number of species, and of evenness, the way species quantities are distributed (van der Maarel, 1979). Species richness is a simple measure, so it has been a popular diversity index in ecology, where abundance data are often not available for the datasets of interest. Because richness does not take the abundances of the types into account, it is not the same thing as diversity, which does take abundances into account.The value of a diversity index increases both when the number of types increases and when evenness increases.

According to Kent and Coker (1992), a diversity index is a mathematical measure of species diversity in a community. The diversity is measured by using diversity index, from the records of the number of species and their relative abundances within the community. A diversity index is a quantitative tool that helps to measure a quantity (for example species) that presents in a dataset. It also takes into account measuring how evenly the basic entities (such as individual species) are distributed among the groups under discussion. Shannon-Wiener Diversity Index and Sorenson's Similarity ratio are important diversity measuring tools being used in plant ecology, because Shannon-Wienner Index can help to calculate species diversity, eqitability and richness of a community or vegetation while Sorensen's Similarity ratio helps to measure the degree of similarity among different plant community types or ecologically related vegetation (Kent and Coker, 1992).

The value of a diversity index from the Shannon-Wiener Diversity Index increases both when the number of types increases and when evenness increases. For a given number of types, the value of a diversity index is maximized when all types are equally abundant (Kent and Coker, 1992). Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account.

2.6. Importance Value Index (IVI) and Dominance

The concept of density, frequency and dominance is very useful tool in the study of plant ecology (van der Maarel, 1979). Species important value, which is measured on the basis of species density, frequency and dominance values permits a comparison of species in the vegetation being studied and reflects the occurrence, dominance and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992). Therefore, measuring the species importantance value is a good index for summarizing vegetation characteristics and ranking the species for management and conservation practices. Species with lower IVI need high conservation efforts whereas those with higher IVI require wise management.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

The study was conducted in Ilu Gelan District, West Shewa Zone of Oromia Regional State, and Central Ethiopia (Figure 1). The District is located on the Addis Ababa-Nekemte main road at about 215 km from Addis Ababa to the west. Ijaji is the central town of the District and is located on geographical coordinates of 08^{o} 59’ 51’’N and 037^{o} 19’ 49’’E with the altitude of 1812 m a.s.l. The District is bordered on the north and the east by Chelia, on the west by Bako Tibe, on the south by Dano districts. It is bordered also on the southwest by Nono Benja of Jimma Zone and Boneya Boshe of East Wollega Zone districts. Gibe River demarcates the boundary of the District on the southwest while Fato River separates it from Dano District on the south. The area of Ilu Gelan District is 65919 hectare (Ilu Gelan District Land Use and Management Office 2017).

This study was conducted in two nearby sites known as Dirki and Jato vegetationsthat are found south of the main road when driving from Gedo, the central town of Chelia District, to Ijaji about 195 km from Addis Ababa to the west. The vegetation of Dirki lies on a steep mountain between the range of latitudes 08^{o}59’16.1’’ to 08^{o}59’50.8’’ N and longitudes 37^{o}22’45.50’’ to 37^{o}23’15.8’’E while that of Jato is found between 08^{o}58’41.5’’ to 08^{o}59’10.8’’ N and 37^{o}21’59.7’’ to 37^{o}22’50.6’’ E (Ilu Gelan District Land Use and Management Office Report 2015).

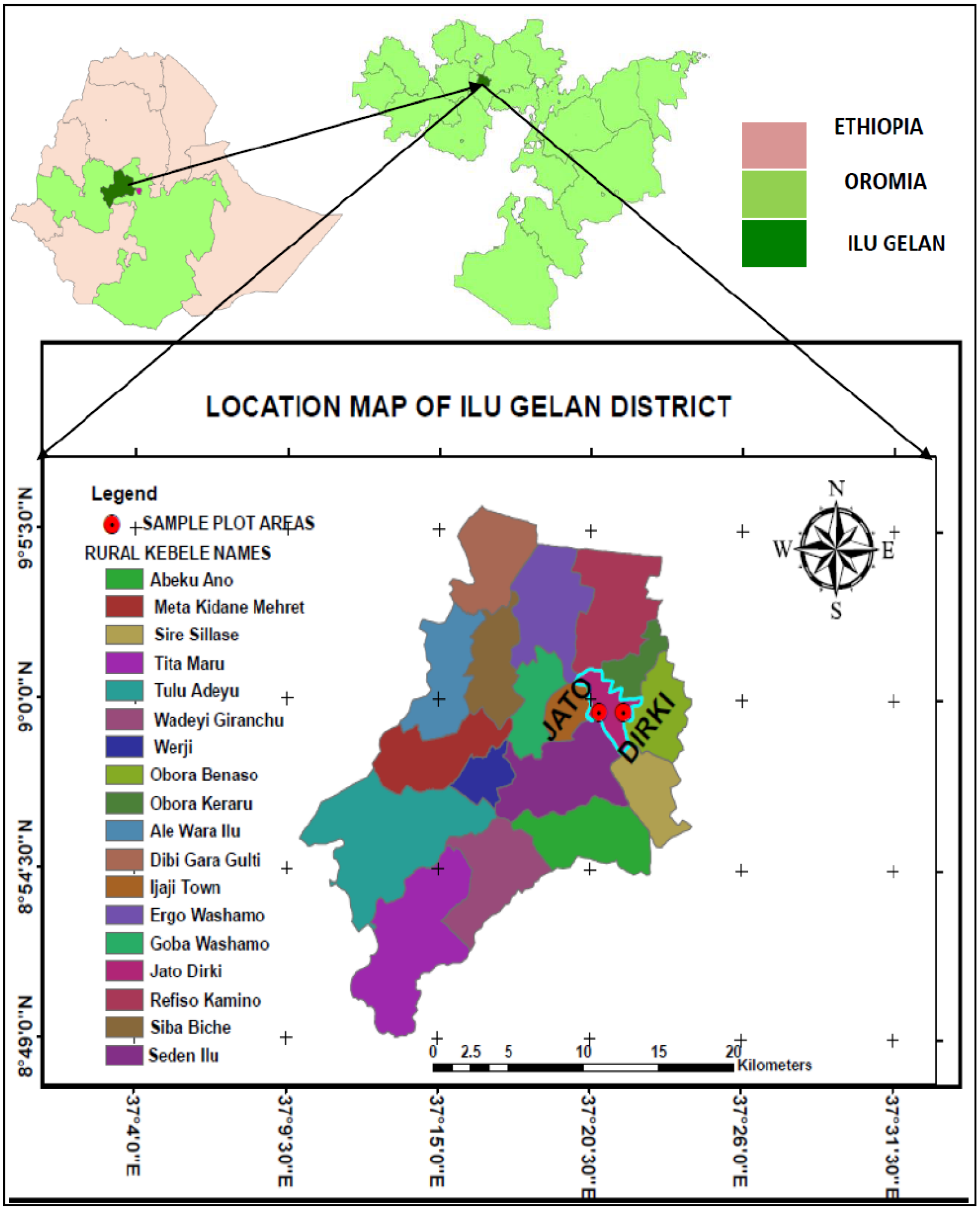

Figure 1: Map of Ethiopia showing Regional States and the study area: source Etho. GIS.www.gov't

3.1.2 Topography

Ilu Gelan District is generally characterized by rough topographic features. It has gorges, escarpments, mountains and plateaus. Mountains known as Tullu Dirki, Tullu Niti and Gara Habib are found in the District. Gara Habib mountain is least covered with vegetation but almost with rocks. The altitudinal range of the District falls within 1500- 2200 m a.s.l. The altitudinal range of Dirki is found between 1795 and 2078 m a.s.l. while that of Jato is between1870 and 2136 m a.s.l. The vegetation of Dirki lies on a steep mountain whereas that of Jato is located on a sloppy escarpment of land face. The vegetation is found on the north and northwest facing parts of the escarpment (Ilu Gelan District Land Use and Management Office Report, 2015).

Four perennial rivers known as Alanga, Washamo, Bisil and Karsa rivers are flowing from the highlands into Gibe River by crossing the District in north to south direction. The water from these rivers provides services for drinking, washing and irrigation. Two mineral water sources, namely, Hora Ambo and Hora Dirki, where the local people use the water to drink their livestock are found in the District (Ilu Gelan District Water Office Report 2016).

3.1.3 Climate

The climate of Ilu Gelan District is considered to belong to the Woina Dega and Kolla agro-ecological zones of Ethiopia. As most parts of the District are found in the low land, the mean annual temperature of the area is relatively high (Endalew Amenu, 2007). Meteorological data obtained from National Meteorology Service Agency (2015), indicates that Ilu Gelan area obtains high rainfall between May and September and low rainfall from December to February (Figure 2). The Climadiagram figure shows that the study area is typical of forest vegetation rainfall distribution. According to the data, the highest mean annual rainfall of the study area recorded for twenty years (1995-2014) was 1351mm and recorded in July, whereas the lowest mean annual rainfall was 11.2 mm and recorded in February. The mean maximum temperature over the twenty years was 28.1 while the mean minimum temperature was 13.8. The highest temperature, 31.7 , was recorded in February, whereas the lowest temperature, 11.2, was recorded in N o v e m b e r .

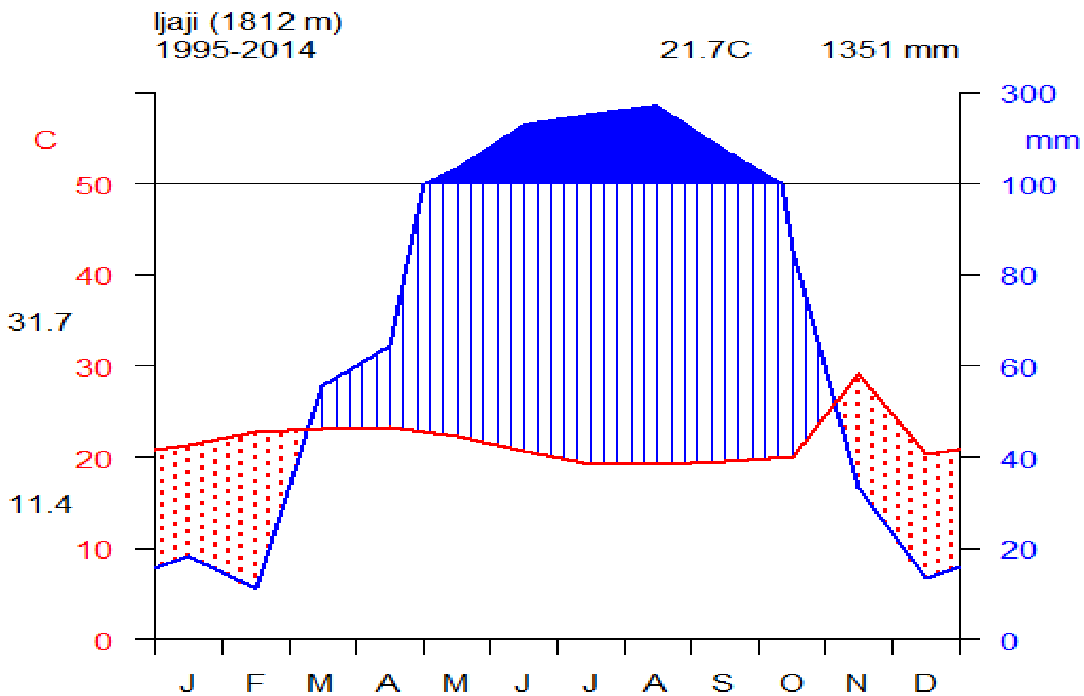

Figure 2: Climadiagram showing rainfall distribution and temperature variationfrom 1995-2014 from around Ijaji Town. Source: National Meteorological Service Agency (2015).

3.1.4. Soil

According to Endalew Amenu (2007), the soil types found in Ilu Gelan District can be classified into four categories.These are red soil (clay soil), black soil, sand soil and a mixture of all the three soil types. The information obtained from the Natural Resource Conservation and Management Office of Ilu Gelan District also reveals as these different types of soils have been identified in the District. The Office realizes that 70% of the proportions of the soils found in the District are categorized under the red soil type while the brown and black soil types cover 25.29% and 4.71%, respectively.The black soil (vertisols) is known to retain large amount of water during wet season while it cracks and looses its water contents during dry season. This type of soil is suitable for teffcultivation in the District. The red and brown soil types, on which most crop production is being practiced in the District, cover large proportions of the soil types. The information obtained from the District indicates that the red and brown soil types are used to cultivate different types of crops such as pepper, sweet potato, maize, sorghum and linseed in the District. Even though the red soil covers the largest portion of the soil types in the District, it is relatively considered poor soil.

3.1.5. Human population

According to the data obtained from the Central Statistical Agency (CSA)(2007), currently the total population of Ilu Gelan District is 77,332 where 39,107(50.57%) of them are males and 38,225(49.43%) are females. From the total population, 66,318 (85.76%) are living in rural areas where, 33,718 (50.84%) of them are males and 32,600 (49.16%) are females. The rest 11,014 (14.24%) of the total population are urban dwellers where 5,389 (48.93%) of them are males and 5,625 (51.07%) are females.

3.1.6. Land use and agriculture

Mixed crop cultivation and livestock rearing are the main agricultural activities of the population of the District. According to the data obtained from the Agricultural Office of the District, different types of crops are cultivated by the farmers. The major crops that are cultivated in the Distric include: *Zea mays* (maize), *Sorghum bicolor*(sorghum), *Eragrostis tef* (teff), *Triticum aestivum* (wheat), *Guizotia abyssinica* (Niger seed), *Hordeum vulgare* (barley), *Linum usitatissimum* (Linseed), *Pisum sativum* (Field pea) and *Vicia faba*(Faba bean). However, *Zea mays* (maize), *Eragrostis tef* (teff) and *Sorghum bicolor* (sorghum) are the leading crops cultivated in the District. Other field cash crops like *Capsicum annuum* and *Capsicum frutescens* (pepper), *Ipomoea batatas* (sweet potato) and *Catha edulis* (chat) are also highly cultivated in the District.

3.1.7. Livestock population

Data obtained from Ilu Gelan District Agricultural Office shows that the District possesses 167,875 livestock population consisting of 105,420 cattle; 7,465 sheep; 8,750 goats; 635 horses; 950 mules; 3,370 donkeys and 41,285 poultry. As most parts of the land are currently occupied by farming, shortage of grazing and browsing land is the main problem for the livestock population. In addition to this, livestock diseases are the main problems of the animal biodiversities in the District (Endale Amenu, 2007).

3.1.8. Vegetation

The information obtained from Ilu Gelan District indicates that most parts of the lands currently, observed as free in the District were covered with vegetation in the past (personal communication)..Today, few remnants of big trees are observed in the farm lands and roadsides. For example, plant species like *Ficus vast*, *Albizia schimperiana*, *Cordia africana*, *Ficus sycomorus, Prunus africana, Croton macrostachyus, Podocarpus falcatus, Olea europaea* and *Ficus sur* are observed in the farm lands and on road sides. It can also be deduced from this respect that the vegetation cover of the District was larger in the past than what is realy observed at the present.

Currently, there are some natural vegetation areas found in the District.These areas are known by the names: Dirki, Jato, Irgo Washamo, Ale Wara Ilu, Obora Benaso, Obora Keraru, Rafiso Kamino, Dibi Gara Gulti and Sire Sillase. They are separated by settlements and almost restricted to mountainous areas and slopes of escarpments. This indicates as most proportions of the vegetation have been removed from areas that are suitable for expansion of agriculture (i.e., bases of mountains and flat lands).

3.1.9. Wildlife

According to the information obtained from Ilu Gelan District Natural Resource Management Office, a variety of wildlife including monkeys, baboons, hyenas, wild pigs, bushbuck, porcupines, leopards, and different snake species are found in the District. Monkeys, baboons, wild pigs and snakes were observed in the vegetation during the data collection. Different types of bird species are also observed in Dirki-Jato vegetations. However, according to the information obtained from local community surrounding the study sites, groups of baboons and hyenas are becoming great threats to their crops, livestock and own lives. According to the local society, demand of food resources by the wildlife is putting pressure on their field crops and the life of domestic animals.

3.2. Methods

3.2.1. Reconnaissance survey

Reconnaissance survey was made during the first week of June 2016 in order to obtain the impressions of the study site conditions and select sampling sites.

3.2.2 Sampling design and vegetation data collection

Woody Vegetation data were taken from 54 quadratslaid systematically along transects that cross cut altitudinal gradient. Quadrats of 20 m x 20 m were laid down along transecst at every 25m altitudinal drop starting from the highest point in four directions (N, W, S and E) in the case of Dirki while on the north and north-west facing aspects of extending escarpment in Jato. Moreover, five 5 m x 5 m subquadrats, one at each of the four corners and one at the center of the 20 m x 20 m main quadrat were also laid to sample seedling and sapling. List of the number of quadrats in each transect along with their locations and altitude records is given in (Appendix 1).In each quadrat,identity of all live woody species (WS), number of live individuals of all WS and diameter at breast height (DBH=1.3m) of all WS (with DBH > 2cm) were recorded. For WS that were branched at around the breast height, the DBH were measured separately and averaged. The woody species were preliminarily identified in the field by using the available literature (e.g. Flora of Ethiopia and Eritrea). Voucher specimens of each WS were collected, dried and pressed for further identification and confirmation of the authenticity in Haramaya University.

3.2.4. Data Analysis

Species Richness, Diversity and Evenness

Species richness was determined from the total number of woody species recorded in sample quadrats. The diversity of woody species was analyzed by using the Shannon-Weiner

Diversity Index (Krebs, 1989; Magurran, 2004). The index takes into account the species richness and proportion of each species in all sampled quadrats of the study site. The value of Shannon-Weiner Diversity Index is usually found to fall between 1.5-3.5 and rarely surpasses 4.5 (Magurran, 1988).

The **Shannon diversity index** was calculated from the following formula:

H' =

Where: H' = Shannon-Wiener Diversity Index; Σ = Summation symbol; p_i = the proportion of individuals or the abundance of i^{th} species expressed as a proportion of total cover in the sampleand ln = log bases (natural logarithms).

Equitability or evenness, a measure of similarity of the abundances of the different woody species in the study site, was analyzed by using Shannon's Evenness or Equitability Index (Krebs, 1989; Magurran, 2004).

Equitability or evenness index was calculated using the following formula.

E = H'/ln (S) = H'/Hmax

Where: E = Evenness; H' = Shannon-Wiener Diversity Index; Hmax = lnS; S = total number of species in the sample. The value of evenness index falls between 0 and 1. The higher the value of evenness index, the more even the species is in their distribution within the given area.

Density, Frequency, Dominance and Important Value Index

Density of the woody species were calculated by converting the total number of individuals of each woody species encountered in all the quadrats and all transects used in the site to equivalent number per hectare.

The **frequency** was calculated as the proportion (%) of the number of quadrats in which each woody species were recorded from the total number of quadrats in the site.

Dominance of the woody species, with diameter at breast height (DBH) of >2cm were determined from the space occupied by a species, usually its basal area. The total basal area of each woody species was converted to equivalent basal area per hectare (Kent and Coker, 1992).

Basal area was calculated by using the following formula.

$$BA = \pi d^2/4$$

Where BA = Basal area in m^2 per hectare

d= diameter at breast height

$\pi = 3.14$

Important Value Index (IVI), which indicates the relative ecological importance of a given woody species at a particular site (Kent and Coker, 1992), was determined from the summation of the relative values of density, frequency and dominance of each woody species. Consequently, Important value index = Relative Density + Relative Dominance + Relative Frequency where:

Relative density was calculated as the percentage of the density of each species divided by the total stem number of all species ha^{-1}.

Relative density = X 100

Relative frequency of a species was computed as the ratio of the frequency of the species to the sum total of the frequency of all species in the study site.

Relative frequency = X 100

Relative dominance was calculated as the percentage of the total basal area of a species out of the total basal area of all species at the study site.

Relative dominance = X 100

Population Structure and Regeneration Status

The population structure of each of the woody species in the study site was assessed through histograms constructed by using the density of individuals of each species (Y-axis) categorized into ten diameter classes (X-axis) (Peters, 1996), i.e. 1=<2cm; 2=2-5cm; 3=5-10cm; 4=10-15cm; 5= 15-20cm; 6= 20-25cm; 7= 25-30cm; 8= 30-35cm; 9= 35-40cm; 10= >40cm. Then, based on the profile depicted in the population structure, the regeneration status of each woody species was determined. Regeneration status of the forest was analyzed by comparing saplings and seedlings with the mature trees according to Dhaulkhandi *et al.* (2008); and Tiwari *et al*. (2010), i.e., Good regeneration, if seedlings >saplings >adults; Fair regeneration, if seedlings> or ≤ saplings ≤ adults; Poor regeneration, if the species survives only in sapling stage, but no seedlings (saplings may be <, > or = adults); and if a species is present only in an adult form it is considered as not regenerating.

Sorensen's (1994) similarity index

Sorensen's similarity index was computed to help comparison between species composition of other similar vegetations of the region. Sorensen's similarity index was computed using the following formula.

$$S_S=$$

Where: S_S = Sorensen's similarity coefficient

a= number of woody species common to Dirki-Jato forest and other forest in comparison

b= number of woody species found only in Dirki-Jato forest

c= number of woody species found only in the forest in comparison with Dirki-Jato forest

4. RESULTS AND DISCUTION

4.1. Floristic Composition

In this study, 106 woody plant species distributed in 84 genera and 49 families were recorded from Dirki- Jato site (Table 2). Out of the total woody plant species recorded, trees comprise 62.26% while shrubs and lianas constitute 33.96% and 3.77%, respectively (Table 1).

Table 1**:** Number and percentage of tree, shrubs and lianas in Dirki-Jato forest.

Habit	Number of species	Percentage
Tree	68	62.26
Shrub	35	33.96
Liana	3	3.77

Of all the families, Fabaceae, Rubiaceae, Euphorbiaceae, Combertaceae and Moraceae were the five most dominant families represented by 11, 6, 6, 2 and 1 genera, respectively, and by 14, 6, 6, 6 and 6 species, respectively. These five dominant families together constituted 38 (35.85%) of the total species richness in Dirki- Jato Vegetations. The next dominant family was Oleaceae with 4(3.77%) species followed by Asteraceae, Lamiaceae, Celastraceae, Loganiaceae, Sapindaceae and Verbenaceae each with 3(2.83%) species.While other 9 families were represented by 2 species each. The rest 28 families each being represented by one species contributed 26.42% of the total species (Appendix2).

The Shannon-Wiener Diversity index (H') and evenness values of Dirki-Jato forest were 3.23, 0.69**,** respectively (Appendix 3)**.** The value of Shannon-Weiner Diversity Index usually found to fall between1.5-3.5 and rarely surpasses 4.5 (Magurran, 1988). The Shannon diversity index values observed in Dirki-Jato forest fall within the range (0.70 - 3.57) reported for other dry forests of the Sub-Saharan region (Shackleton, 1993; Obiri *et al*., 2002; Venter & Witkowski, 2010). Based on this assumption, the diversity index obtained for this forest shows that Dirki-Jato forest has high diversity with the different species having fairly uniform abundance.The high diversity of woody plants in Dirki-Jato forest was probably a result of high species richness and abundance of this study area (Appendix 3).

Table 2: Woody plant species of the study site with their mean density (ha^{-1}), frequency (%), DBH (cm) and basal area (m^2 ha^{-1})

No	Scientific Name	Family	Local Name	Habit	Mean D	Mean F	Mean DBH	Mean BA
1	*Abutilon longicuspe* Hoehst. exA. Rich.	Malvaceae	Hincinnii	S	57.59	16.67	**3.50**	0.024
2	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	Laaftoo	T	46.386	25.93	20.54	0.828
3	*Acacia etbaica* Schweinf.	Fabaceae	Doddota	T	65.51	33.33	20.36	0.814
4	*Acacia persiciflora* Pax	Fabaceae	Garbii	T	62.75	35.19	21.12	0.875
5	*Acanthus sennii* Chiov.	Acanthaceae	Sokorruu	S	263.79	55.56	3.00	0.018
6	*Albizia schimperiana* Oliv.	Fabaceae	Imalaa	T	79.45	59.26	23	1.038
7	*Allophylus macrobotrys* Gilg	Sapindaceae	Sarara	T	79.45	57.41	11.25	0.248
8	*Allophylus africanus* P. Beauv.	Sapindaceae	Qarxammee	T	14.07	11.11	15	0.442
9	*Apodytes dimidiata* E. Mey. ex Am.	Icacinaceae	Qumbaala	T	57.89	16.67	12.35	0.299
10	*Bersama abyssinica* Fresen.	Melianthaceae	Lolchiisaa	T	66.96	22.22	12.85	0.324
11	*Bridelia micrantha* (Hochst.) Baill.	Euphorbiaceae	Agiraabaa	T	126.03	51.85	11.55	0.262
12	*Brucea antidysenterica* J.F.Mill.	Simaroubaceae	Qomonyoo	S	112.22	44.44	3.95	0.031

13	*Buddelja davidii* Franch.	Loganiaceae	Qawwwisa	S	58.48	24.07	10	0.196
14	*Buddleja polystachya* Fresen.	Loganiaceae	Qawwisa	T	63.26	25.93	10.25	0.206
15	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	Ceekaa	S	285.5	27.78	10.34	0.21
16	*Capparis tomentosa* Lam.	Capparidaceae	Arangamaa	S	510	61.11	3.50	0.024
17	*Carissa spinarum* L.	Apocynaceae	Agamsa	S	245.75	33.33	3.00	0.018
18	*Celtis africana* Burm.f.	Ulmaceae	Cayii	T	349	61.11	10.00	0.196
19	*Chionanthus mildbraedii* (Gilg &Schellenb.) Stearn	Oleaceae	Ka. waayyuu	T	11.79	9.26	12.00	0.283
20	*Clausena anisata* (Willd). Benth.	Rutaceae	Ulmaayii	S	213	29.63	3.33	0.022
21	*Clematis longicauda* Steud.ex A. Rich.	Ranunculaceae	Hidda fiitii	L	100	37.04	3.00	0.018
22	*Clematis simensis* Fresen.	Ranunuclaceae	Hidda fiitii	L	80	25.93	3.02	0.018
23	*Clerodendrum myricoides*(Hochst.) Vatke	Verbenaceae	Maraasisaa	S	34.72	20.37	5.00	0.049
24	Clutia abyssinica Jab.&-Spach	Euphorbiaceae		S	240.74	31.48	6.00	0.071
25	Combretum adenogonium Steud. ex A. Rich.	Combretaceae	Rukeessa	T	45.52	24.07	13.00	0.332
26	Combretum collinun Fresen	Combretaceae		T	46.30	22.22	11.00	0.237

27	*Combretum molle* R. Br. ex G.Don	Combertaceae	Rukeessa	T	45.75	22.22	12.00	0.283
28	*Combretum nigrican Lepr.ex Guill.& per*	Combertaceae		T	26.76	11.11	15.00	0.442
29	*Cordia africana* L.	Boraginaceae	Waddeessa	T	5.79	5.56	50.75	5.055
30	*Crotalaria rosenii(Pax) Milne-Redh.ex polhill*	Fabaceae		S	46.76	29.63	9.21	0.166
31	*Croton macrostachyus* Del.	Euphorbiaceae	Bakkanniissa	T	20.57	16.67	20.65	0.837
32	*Dalbergia lactea* Vatke	Fabaceae	Sarxee	T	65.15	18.52	11.50	0.26
33	*Dodonaea angustifolia* L. f.	Sapindaceae	Ittacha	S	89	24.07	9.13	0.164
34	*Dombeya torrida* (G.F. Gmel.) P. Bamps	Sterculiaceae	Daannisa	T	129	14.81	11.14	0.244
35	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacourtiaceae	Koshommii	T	5.32	3.70	8.54	0.143
36	*Dracaena steudneri* Engl.	Dracaenaceae	Meerqoo	S	55	12.96	9.25	0.168
37	*Ehretia cymosa* Thonn.	Boraginaceae	Ulaagaa	T	28.13	8.14	12.00	0.283
38	*Ekebergia capensis* Sparrm.	Meliaceae	Somboo	T	10.65	7.41	23.25	1.061
39	*Eucalyptus camaldulensisDehnh.*	Myrtaceae	Baar. Diimaa	T	66.59	27.78	18.00	0.636
40	*Euclea divinorum Hiern*	Ebenaceae	Mi’essa	T	33.10	12.96	12.00	0.283

41	*Entada abyssinica* Steud. exA. Rich.	Fabaceae	Ambaltaa	T	167.61	51.85	24.00	1.13
42	*Erythrococca abyssinica* Pax	Euphorbiaceae	Geelloo	S	32.93	14.81	9.95	0.194
43	*Ficus mucuso* Ficalho.	Moraceae	Qilinxoo	T	15	11.11	26.56	1.384
44	*Ficus salicifolia* A. Rich.	Moraceae	Qilinxoo	T	35.92	9.26	23.00	1.038
45	*Ficus sur* Forssk.	Moraceae	Harbuu	T	7.20	5.56	22.75	1.016
46	*Ficus sycomorus* L.	Moraceae	Odaa	T	8.25	9.26	32.25	2.041
47	*Ficus thonningii* Blume	Moraceae	Dambii	T	6.34	11.11	20.20	0.801
48	*Ficus vasta* Forssk.	Moraceae	Qilxuu	T	8.5	7.41	27.00	1.431
49	*Flacourtia indica* (Burm.f.) Merr	Flacourtaceae	Akuukkuu	T	38.15	24.07	13.00	0.332
50	*Galiniera saxifraga* (Hochst.) Bridson	Rubiaceae	Buniitii	T	24.43	20.37	9.75	0.187
51	*Gardenia ternifolia* Schumach. &Thonn.	Rubiaceae	Gambeela	T	39.62	57.41	20.22	0.802
52	*Gnidia glauca* (Fresen.) Gilg	Thymelaeaceae	Qaqaroo	S	20.27	29.63	8.00	0.126
53	*Grewia ferruginea* Hochst.ex A. Rich.	Tiliaceae	Dhoqonuu	T	163.75	35.19	7.75	0.118
54	*Hymenodictyonfloribundum* (Hochst. & Steud.) Robinson	Rubiaceae	Gaarrii	T	5.29	5.56	20.00	0.785

55	*Hypericum quartinionum A. Rich*	Hypericaceae	Hinee	T	5.56	9.26	8.20	0.132
56	*Ilex mitis L.Radlk.*	Aquifoliaceae		T	26.29	11.11	7.90	0.122
57	*Lantana trifolia L.*	Verbenaceae	Ba. argatte	S	28.93	18.52	3.32	0.022
58	*Lippia adoensis* Hochst. ex Walp	Verbenaceae	Kusaayee	S	193.88	42.59	3.24	0.021
59	*Maesa lanceolata* Forssk.	Myrsinaceae	Abbayyii	T	241.34	59.26	4.08	0.033
60	*Maytenus arbutifolia* (A.Rich.) Wilczek	Celastraceae	Kombolcha	S	354	90.74	9.26	0.168
61	*Maytenus gracilipes* (Welw. ex Oliv.) Exell	Celastraceae	Acaacii	S	376.64	94.44	3.22	0.02
62	*Maytenus obscura* (A. Rich.) Cuf.	Celastraceae	Kombolcha	S	237.23	88.89	8.27	0.134
63	*Millettia ferruginea* (Hochst.) Bak.	Fabaceae	Birbirra	T	74.80	29.62	20.24	0.804
64	*Mimosa pigra* L.	Fabaceae	Arangamaa	S	36.94	18.52	3.34	0.022
65	*Mimusops kummel* A. DC.	Sapotaceae	Qolaatii	T	55.79	20.37	16.25	0.518
66	*Myrsine africana* L.	Myrsinaceae	Qacama	S	142.51	33.33	10.14	0.202
67	*Nuxia congesta* R.Br. ex Fresen.	Loganiaceae	Qawwisa	T	150	75.93	15.73	0.486
68	*Ocimum lamiifolium* Hochst. ex. Benth.	Lamiaceae	Anc. diimaa	S	107	33.33	3.00	0.018

69	*Ocimum urticifolium* Roth.	Lamiaceae	Ancabbii adii	S	65.73	29.63	2.99	0.018
70	*Olea capensi*Lsubsp.*macrocarpa* (C.H. Wright) Verdc.	Oleaceae	Gagamaa	T	15	16.67	9.12	0.163
71	*Olea europaea* L. subsp. *cuspidata* (Wall.ex G.Don) Cif.	Oleaceae	Ejersa	T	19	24.07	20.50	0.825
72	*Olinia aequipetala(Delile)* Cuf	Oliniaceae	Daalachoo	T	170	61.11	12.93	0.328
73	*Osyris quadripartita* Decne	Santalaceae	Waatoo	T	110.60	33.33	18.00	0.636
74	*Periploce llnearlfolia Quart.Dill A.Rich*	Asclepiadaceae	H. aannanno	L	102	27.68	2.90	0.017
75	*Phoenix reclinata* Jacq.	Palmae	Meexxii	T	105	25.93	18.20	0.65
76	*Pliostigma thonningii(Schumach.) Milne-Redh*	Fabaceae		T	70.75	22.22	10.00	0.196
77	*Phytolacca dodecandra L'Herit.*	Phytolaccaceae	Andoodee	S	12	7.41	2.89	0.016
78	*Podocarpus falcatus*(Thunb.) R.B. ex. Mirb.	Podocarpaceae	Birbirsa	T	15.87	14.81	21.00	0.865
79	*Premna schimperi* Engl.	Lamiaceae	Urgeessaa	S	372	53.70	12.00	0.283
80	*Prunus Africana* (Hook.f.) Kalkm.	Rosaceae	Hoomii	T	4.58	7.41	22.83	1.023
81	*Pterolobium stellantum (Foressk.) Brenan*	FAbaceae	Harangamaa	T	252.97	35.19	2.95	0.017

82	*Psychotria orophila Petit*	Rubiaceae		S	35.16	12.96	8.83	0.153
83	*Rhus natalensis* Krauss	Anacardiaceae	Xaaxessaa	T	243.27	46.30	19.00	0.708
84	*Rhus vulgaris* Meikle	Anacardiaceae	Xaaxessaa	T	239	44.44	16.76	0.551
85	*Ricinus communis* L.	Euphorbiaceae	Qobboo	S	33.59	20.37	10.40	0.212
86	*Rosa abyssinica* Lindley	Rosaceae	Qaqawwii	S	297	42.59	9.50	0.177
87	*Rothmannia urcelliformis* (Hiem) Robyns	Rubiaceae	Qola-gurraa	T	55	33.33	8.90	0.155
88	*Rytigynia neglecta* (Hiera) Robuns	Rubiaceae	Mixoo	S	209.62	35.19	4.00	0.031
89	*Salix mucronata* Thunb. (S. subserrata Willd)	Salicaceae	Alaltuu	T	77.47	27.78	9.15	0.164
90	*Sapium ellipticum* (Krauss) Pax.	Euphorbiaceae	Bosoqa	T	59	20.37	5.54	0.06
91	*Schefflera abyssinica*(Hochst. ex A. Rich.) Harms	Araliaceae	Gatamaa	T	20.17	14.81	17.53	0.603
92	*Schrebera alata* (Hochst.) Welw.	Oleaceae	Qana'ee	T	57.31	37.04	20.33	0.811
93	*Scutia myrtina* (Burm. f.) Kurz	Rhamnaceae	Kombolcha	S	33.65	20.37	11.00	0.237
94	*Senna petersiana* (Bolle) Lock	Fabaceae	Gaafatoo	T	48.63	16.67	10.22	0.205
95	*Senn obtusifolia L.*	Fabaceae		T	60.66	24.07	8.33	0.136

96	*Sida rhombifolia L.*	Malvaceae	Karabaa	S	106.94	38.89	9.25	0.168
97	*Solanum marginatum L.f.*	Solanaceae	H. hongorcaa	S	56.95	14.81	2.99	0.018
98	*Stereospermum kunthianum* Cham.	Bignoniaceae	Botoroo	T	58.11	18.52	20.00	0.785
99	*Syzygium guineense* (Willd.) DC.	Myrtaceae	Baddeessaa	T	120	48.15	21.14	0.877
100	*Teclea nobilis* Del.	Rutaceae	Hadheessa	T	41.45	20.37	17.00	0.567
101	*Terminalia macroptera* Guill & Perr.	Combretaceae	Dabaqqaa	T	85	27.78	12.00	0.283
102	*Terminalia schimperiana* Hochst.	Combretaceae	Gaarrii	T	30.74	18.52	19.50	0.746
103	*Vangueria apiculata* K. Schum.	Rubiaceae	Buruurii	S	77.38	20.07	11.00	0.237
104	*Vernonia amygdalina* Del.	Asteraceae	Eebicha	T	50.37	22.22	18.00	0.636
105	*Vernonia leopoldi (Sch.Bip.ex Walp.) Vatke*	Asteraceae		S	73.96	18.52	16.54	0.537
106	*Vernonia myriantha Hook.f.*	Asteraceae	Reejjii	T	168.54	55.56	17.32	0.589

Key: BA= basa area, D= density, DBH= diameter at breast height, F= frequency, L= liana, S= shrub, T= tree

Out of the plants collected from the study area, 7 were endemic species (Table 2). These endemic species accounted for 6.60% of the total floristic composition of the area, of which shrubs represent 4.72% and trees 0.94% and Lianas 0.94%. Endemic plant species of Ethiopia and their level of threat have been given in Ensermu *et al.* (1992) and Vivero *et al.* (2005). According to Vivero *et al.* (2004; 2005 and 2006), some of these endemic plant species are listed in IUCN Red Data List. Therefore, identifying and knowing these species assist us to give conservation priority and effective management.

Table 3: List of endemic species in the study area with their habit and conservation status

Species	Family	Habit	IUCN category
Acanthus sennii Chiov.	Acanthaceae	S	NT
Clematis longicauda Steud.ex A. Rich.	Ranunculaceae	L	LC
Crotalaria rosenii (Pax) Milne-Redh.ex Polhill	Fabaceae	S	NT
Lippia adoensis Hochst. ex Walp	Verbenaceae	S	LC
Millettia ferruginea (Hochst.) Bak.	Fabaceae	T	NT
Solanum marginatum L.f.	Solanaceae	S	LC
Vernonia leopoldi (Sch. Bip. ex Walp.) Vatke	Asteraceae	S	LC

(T= tree, S= shrub, L= liana), IUCN Threat categories (NT= Near Threatened, LC= Least Concern).

Sorenson's coefficient of similarity was computed to compare the similarity in family, genera and species composition of Dirk-Jato woody vegetation with some other similar afromontane forests of the country. Results showed that the highest similarity (76.12%) in family composition was observed between Dirki-Jato and Senka Meda Forest, followed by that of Angada (71%) and Denkoro (65%) forests. The same similarity trend was also seen in terms of species and genera composition. Least similarity in species composition was observed with vegetation of Mana Angetu (37%) (Table 4).The probable reasons for variation in floristic composition between Dirki-Jato and Mana Angetu and Yayu vegetations could be due to variation between the sites in extent of anthropogenic disturbance, excessive exploitation of same species and variation in environental conditions for regeneration. Anthropogenic disturbances, such as logging or cutting trees, usually, result in an immediate decline in species diversity (Noble and Dirzo, 1997).

Table 4: Sorenson's coefficient of similarity (%) in family, genus and species composition with other studies made in similar afromontane vegetations of the country

Taxa/Study site	Study site					
Species	Dirk and Jato (1795-2136)	Yayu 1200-2000	Mana Angetu 2440-3400	Denkoro (1500-3500)	Angada (2145-2562)	Senka meda (1200-3574)
Dirk and Jato	-	43.58	37	48	50.6	51.43
Yayu		-	57	64	49	57.5
Mana Angetu			-	56.4	46	38
Denkoro				-	61	53.6
Angada					-	53
Senka meda						-
Genera						
Dirk and Jato	-	39.59	53	43	58	64
Yayu		-	47.9	32	21	40
Mana Angetu			-	26	43.4	41.76
Denkoro				-	36	53
Angada					-	57
Senka meda						-
Family						
Dirk and Jato	-	33.5	55	65	71	76.12
Yayu		-	62	41	43	64
Mana Angetu			-	62	56.4	55.5
Denkoro				-	47.7	69

Angada	-	58
Senka meda		-

4.2. Density, Frequencyand Dominance of Woody Plant Species

Density is expressed as the number of plants per unit area and it is a crucial parameter for sustainable forest management. When put together, the mean density of all the woody species with DBH>2 cm recorded in Dirk-Jato vegetation was 10202.37 individuals ha^{-1}. Of all recorded species*, Maytenus gracilipes* was the most dense (376.64 individuals' ha^{-1}) followed by *Permna schimperi* (372 individualas' ha^{-1}) and *Maytenus arbutifolia* (354 individuals' ha^{-1}) (Table 2).The mean density of each recorded species was also seen against DBH and the result showed that number of individuals varied with DBH (Table 2).

Frequency is defined as the number of quadrats in which a particular species occurs in a study area. It is obtained by dividing the number of quadrats in which the species occurred by the total number of the quadrats from which all the species were sampled in the area under the study.The percentage frequency was computed for each woody plant species.The result showed that the three most frequen tspecies were *Maytenus gracilipes* (94.44%), *Maytenus arbutifolia* (90.74%) and *Maytenus obscura* (88.89%) and the three least frequent species were *Dovyalis abyssinica* (3.70%), *Fucus sur* (5.56%), *and Hymenodictyon floribum* (5.56%) (Table 2).

Dominance of the woody species, with diameter at breast height (DBH) of >2 cm, was determined from the space occupied by a species, usually its basal area. The total basal area of each woody species was converted to equivalent basal area per hectare. Basal area of all woody species added up to 45.87 m^2 ha^{-1}. The most dominant woody species in the forest were *Cordia africana* (11.03%) followed by *Ficus sycomorus* (4.45%), *Ficus vasta* (3.12%), *Ficus mucuso* 3.01%) *and Prunus africana* (2.22%)(Table 2).

4.3. Important Value Index (IVI)

Important value index (IVI) was calculated from the summation of the relative dominance, relative frequency and relative density values of each woody species and results are shown in (Table 5). It indicates the relative ecological importance of a given woody species at a particular site (Kent & Coker 1992). Results show that *Cordia africana* was found to have the highest IVI value (11.26) followed by *Maytenus arbitifolia* and *Maytenus graiclipes* (6.71) each and *Permna schimperi* (5.96) (Table 5). Relatively, the higher IVI of these species is due to their high values of density, frequency and dominance. This suggests that these species are important species of Dirk-Jato forest and play crucial role for the ecological functioning of the area. They are species that are well adapted to the environmental factors of the area and need to be monitored to maintain healthier interaction between components of that ecosystem. Many researchers (e.g., Zegeye *et al.,* 2006; Senbeta and Teketay, 2003; Worku *et al.,* 2012) explain that IVI is an important parameter that indicates the ecological significance of species in agiven ecosystem. If a species has high IVI value, it will be regarded as more important than those with low IVI values (Zegeye *et al.,* 2011). According to Shibiru and Balcha (2004), IVI value helps to set conservation program in such a way that species with low IVI value will be given conservation priority. In the current study area, the least IVI value was recorded for *Phytolacca dodecandra (0.38), Dovyalis abyssinica (0.48*) and *Hypericum quartinionum* (0.63) suggesting that this species need attention for conservation (Table 5).

Table 5: Woody plant species of the study site with their relative density, relative frequency, relative basal area and important value index

No	Scientific Name	Habit	RD	R F	RBA	IVI
1	*Abutilon longicuspe* Hoehst. exA. Rich.	S	0.56	0.53	0.052	1.142
2	*Acacia abyssinica* Hochst. ex Benth.	T	0.45	0.82	1.805	3.075
3	*Acacia etbaica* Schweinf.	T	0.64	1.05	1.774	3.464
4	*Acacia persiciflora* Pax	T	0.62	1.11	1.908	3.638
5	*Acanthus sennii* Chiov.	S	2.59	1.76	0.039	4.389
6	*Albizia schimperiana* Oliv.	T	0.78	1.87	2.263	4.913
7	*Allophylus macrobotrys* Gilg	T	0.78	1.81	0.541	3.131
8	*Allophylus africanus* P. Beauv.	T	0.14	0.35	0.963	1.453
9	*Apodytes dimidiata* E. Mey. ex Am.	T	0.57	0.53	0.653	1.753
10	*Bersama abyssinica* Fresen.	T	0.66	0.7	0.706	2.066
11	*Bridelia micrantha* (Hochst.) Baill.	T	1.24	1.64	0.571	3.451
12	*Brucea antidysenterica* J.F.Mill.	S	1.1	1.4	0.067	2.567
13	*Buddelja davidii* Franch.	S	0.57	0.76	0.428	1.758
14	*Buddleja polystachya* Fresen.	T	0.62	0.82	0.449	1.889
15	*Calpurnia aurea* (Ait.) Benth.	S	2.8	0.88	0.457	4.137

16	*Capparis tomentosa* Lam.	S	5	1.93	0.052	6.982
17	*Carissa spinarum* L.	S	2.41	1.05	0.039	3.499
18	*Celtis africana* Burm.f.	T	3.42	1.93	0.428	5.778
19	*Chionanthus mildbraedii* (Gilg &Schellenb.) Stearn	T	0.12	0.29	0.616	1.026
20	*Clausena anisata* (Willd). Benth.	S	2.09	0.94	0.047	3.077
21	*Clematis longicauda* Steud.ex A. Rich.	L	0.98	1.17	0.039	2.189
22	*Clematis simensis* Fresen.	L	0.78	0.82	0.039	1.639
23	*Clerodendrum myricoides*(Hochst.) Vatke	S	0.34	0.64	0.107	1.087
24	Clutia abyssinica Jab.&-Spach	S	2.36	0.99	0.154	3.504
25	Combretum adenogonium Steud. ex A. Rich.	T	0.45	0.76	0.723	1.933
26	Combretum collinun Fresen	T	0.45	0.7	0.518	1.668
27	*Combretum molle* R. Br. ex G.Don	T	0.45	0.7	0.616	1.766
28	*Combretum nigrican Lepr.ex Guill.& perr*	T	0.26	0.35	0.963	1.573
29	*Cordia africana* L.	T	0.06	0.18	11.02	11.26
30	*Crotalaria rosenii(Pax) Milne-Redh.ex polhill*	S	0.46	0.94	0.363	1.763
31	*Croton macrostachyus* Del.	T	0.2	0.53	1.824	2.554
32	*Dalbergia lactea* Vatke	T	0.64	0.59	0.566	1.796

33	*Dodonaea angustifolia* L. f.	S	0.87	0.76	0.357	1.987
34	*Dombeya torrida* (G.F. Gmel.) P. Bamps	T	1.26	0.47	0.531	2.261
35	*Dovyalis abyssinica* (A. Rich.) Warb.	T	0.05	0.12	0.312	0.482
36	*Dracaena steudneri* Engl.	S	0.54	3.85	0.366	4.756
37	*Ehretia cymosa* Thonn.	T	0.28	0.26	0.616	1.156
38	*Ekebergia capensis* Sparrm.	T	0.1	0.23	2.313	2.643
39	*Eucalyptus camaldulensisDehnh*.	T	0.65	0.88	1.386	2.916
40	*Euclea divinorum Hiern*	T	0.32	0.41	0.616	1.346
41	*Entada abyssinica* Steud. exA. Rich.	T	1.64	1.64	2.464	5.744
42	*Erythrococca abyssinica* Pax	S	0.32	0.47	0.424	1.214
43	*Ficus mucuso* Ficalho.	T	0.15	0.35	3.018	3.518
44	*Ficus salicifolia* A. Rich.	T	0.35	0.29	2.263	2.903
45	*Ficus sur* Forssk.	T	0.07	0.18	2.214	2.464
46	*Ficus sycomorus* L.	T	0.08	0.29	4.45	4.82
47	*Ficus thonningii* Blume	T	0.06	0.35	1.746	2.156
48	*Ficus vasta* Forssk.	T	0.08	0.23	3.119	3.429
49	*Flacourtia indica* (Burm.f.) Merr	T	0.37	0.76	0.723	1.853
50	*Galiniera saxifraga* (Hochst.) Bridson	T	0.24	0.64	0.407	1.287

51	*Gardenia ternifolia* Schumach. &Thonn.	T	0.39	1.81	1.749	3.949
52	*Gnidia glauca* (Fresen.) Gilg	S	0.2	0.94	0.274	1.414
53	*Grewia ferruginea* Hochst.ex A. Rich.	T	1.61	1.11	0.257	2.977
54	*Hymenodictyonfloribundum* (Hochst. & Steud.) Robinson	T	0.05	0.18	1.711	1.941
55	*Hypericum quartinionum A. Rich*	T	0.05	0.29	0.288	0.628
56	*Ilex mitis L.Radlk.*	T	0.26	0.35	0.267	0.877
57	*Lantana trifolia L.*	S	0.28	0.59	0.047	0.917
58	*Lippia adoensis* Hochst. ex Walp	S	1.9	1.35	0.045	3.295
59	*Maesa lanceolata* Forssk.	T	2.37	1.87	0.071	4.311
60	*Maytenus arbutifolia* (A.Rich.) Wilczek	S	3.47	2.87	0.367	6.707
61	*Maytenus gracilipes* (Welw. ex Oliv.) Exell	S	3.69	2.98	0.044	6.714
62	*Maytenus obscura* (A. Rich.) Cuf.	S	2.33	2.81	0.293	5.433
63	*Millettia ferruginea* (Hochst.) Bak.	T	0.73	0.94	1.753	3.423
64	*Mimosa pigra* L.	S	0.36	0.59	0.048	0.998
65	*Mimusops kummel* A. DC.	T	0.55	0.64	1.13	2.32
66	*Myrsine africana* L.	S	1.4	1.05	0.44	2.89
67	*Nuxia congesta* R.Br. ex Fresen.	T	1.47	2.4	1.059	4.929

68	*Ocimum lamiifolium* Hochst. ex. Benth.	S	1.05	1.05	0.039	2.139
69	*Ocimum urticifolium* Roth.	S	0.64	0.94	0.038	1.618
70	*Olea capensi*Lsubsp.*macrocarpa* (C.H. Wright) Verdc.	T	0.15	0.53	0.356	1.036
71	*Olea europaea* L. subsp. *cuspidata* (Wall.ex G.Don) Cif.	T	0.19	0.76	1.798	2.748
72	*Olinia aequipetala(Delile)* Cuf	T	1.67	1.93	0.715	4.315
73	*Osyris quadripartita* Decne	T	1.08	1.05	1.386	3.516
74	*Periploce llnearlfolia Quart.Dill A.Rich*	L	1	0.87	0.036	1.906
75	*Phoenix reclinata* Jacq.	T	1.03	0.82	1.417	3.267
76	*Pliostigma thonningii(Schumach.) Milne-Redh*	T	0.69	0.7	0.428	1.818
77	*Phytolacca dodecandra L'Herit.*	S	0.12	0.23	0.036	0.386
78	*Podocarpus falcatus*(Thunb.) R.B. ex. Mirb.	T	0.16	0.47	1.887	2.517
79	*Premna schimperi* Engl.	S	3.65	1.7	0.616	5.966
80	*Prunus Africana* (Hook.f.) Kalkm.	T	0.04	0.23	2.23	2.5
81	*Pterolobium stellantum (Foressk.) Brenan*	T	2.48	1.11	0.037	3.627
82	*Psychotria orophila Petit*	S	0.34	0.41	0.334	1.084
83	*Rhus natalensis* Krauss	T	2.38	1.46	1.545	5.385

84	*Rhus vulgaris* Meikle	T	2.34	1.4	1.202	4.942
85	*Ricinus communis* L.	S	0.33	0.64	0.463	1.433
86	*Rosa abyssinica* Lindley	S	2.91	1.35	0.386	4.646
87	*Rothmannia urcelliformis* (Hiem) Robyns	T	0.54	1.05	0.339	1.929
88	*Rytigynia neglecta* (Hiera) Robuns	S	2.05	1.11	0.068	3.228
89	*Salix mucronata* Thunb. (S. subserrata Willd)	T	0.76	0.88	0.358	1.998
90	*Sapium ellipticum* (Krauss) Pax.	T	0.58	0.64	0.131	1.351
91	*Schefflera abyssinica*(Hochst. ex A. Rich.) Harms	T	0.2	0.47	1.315	1.985
92	*Schrebera alata* (Hochst.) Welw.	T	0.56	1.17	1.768	3.498
93	*Scutia myrtina* (Burm. f.) Kurz	S	0.33	0.64	0.518	1.488
94	*Senna petersiana* (Bolle) Lock	T	0.48	0.53	0.447	1.457
95	*Senn obtusifolia L.*	T	0.59	0.76	0.297	1.647
96	*Sida rhombifolia L.*	S	1.05	1.23	0.366	2.646
97	*Solanum marginatum L.f.*	S	0.56	0.47	0.038	1.068
98	*Stereospermum kunthianum* Cham.	T	0.57	0.59	1.711	2.871
99	*Syzygium guineense* (Willd.) DC.	T	1.18	1.52	1.912	4.612
100	*Teclea nobilis* Del.	T	0.41	0.64	1.236	2.286

101	*Terminalia macroptera* Guill & Perr.	T	0.83	0.88	0.616	2.326
102	*Terminalia schimperiana* Hochst.	T	0.3	0.59	1.627	2.517
103	*Vangueria apiculata* K. Schum.	S	0.76	0.63	0.518	1.908
104	*Vernonia amygdalina* Del.	T	0.49	0.7	1.386	2.576
105	*Vernonia leopoldi (Sch.Bip.ex Walp.) Vatke*	S	0.72	0.59	1.17	2.48
106	*Vernonia myriantha Hook.f.*	T	1.65	1.76	1.283	4.693

4.4. Population Structure and Regeneration Status of Dirki-Jato Forest

Woody species of Dirki-Jato forest were sub-divided into 5 DBH classes (Fig.3). Comparison between the DBH classes in terms of density showed that the majority, about 22.9% of the total counted individuals of the entire species fall within DBH class of >20cm followed by 22.4% for those with DBH class of 15.01-20.0cm, 19.9% for those with DBH class of 10.01-15cm and 18.2% for those with DBH class of 5.01-10.0cm. The density of individuals of the entire species with DBH class <5cm accounted only for 16.6%. This result shows that total number of woody species was found to increase with increasing DBH, suggesting that mature/older trees were more in number thanseedlings and saplings woody species. This in turn shows that the vegetation of Dirki-Jato is generally in poor regeneration status (Fig.3).

Figure 3: Population structure of woody Species of Dirki- Jato forest

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. Summury

Dirki-Jato is one of the dry evergreen Afromontane forests in Ethiopia. Ecological study of this vegetation was studied with the objective of assessing woody species composition and dominancefor designing of meaningful conservation strategies. Results showed that there are a total of 106 plant species belonging to 84 genera and 49 families in the study area. From the collected specimens, trees were estimated to cover 62.26%, shrub 33.96% and lianas 3.77%. Top five plant families with the highest percentages of the total recorded species were Fabaceae 14(13.21%) followed by Euphorbiaceae, Rubiaceae, Combortaceae and Moraceae each with 6 spp (5.66%). The total basal area of the study area as calculated from DBH data was 45.87m^2ha^{-1}. The overall density of trees, shrubs and lianas species which had DBH >2cm was 10202.37individuals'ha^{-1}. The density of trees, shrubs and lianas increase with increasing DBH.The importance value index (IVI) of the most common and frequent trees was calculated and *Cordia africana* was found to have the highest IVI (11.26) followed by *Maytenus arbutifolia* and *Maytenus gracilipes* (6.71) each (Table 4).

5.2. Conclusion

- Dirki-Jaro forest consists of 106 species of plants belonging to 84 genera and 49 families.
- Fabaceae, Rubiaceae, Ephorbiaceae Combortaceae and Moraceae were found to be the most dominant family followed by Asteraceae and Lamiaceae, Celastraceae, Logniaceae, Sapindaceae and Verbenaceae.
- Of the total species, 7 species are endemic to Ethiopia.

- Dirki-Jato forest has high diversity with the different specieshaving fairly uniform abundance.
- Dirki-Jaro forest has poor regeneration status due to the predominance of large sized individuals in this forest.
- The density of woody species increase with increasing DBH and height indicating that the Forest is in a poor state of reproduction.

5.3. Recommendations

Dirki-Jato forest provides important economic and social value to the rural communities living in and around the area. To minimize the present human influence on this important area and for the future management of the study area in a sustainable manner, the following recommendations are made:

- Raising awareness of local communities on the value of forest resources and ecological consequences of deforestation and device mechanisms by which human impacts can be minimized through discussion and consultation with the local communities.
- The present study was limited to Woody Species Composition and structure in Vegetation of Dirki-Jato Forest thus, further studies on soil seed bank, seed physiology, and land use management system in the area are recommended.

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7. APPENDICES

Appendix Table 1: Location of vegetation data collection in Ilu Gelan District of West Shewa Zone, Oromia Region

Site	Transect	No. of Quadrats	Altitude	Latitude	Longitude	Aspect
Dirki	Peak	1	2078 m a.s.l.	08^{o}59’31.7’’	037^{o}23’07.1’’	Peak
	1	11	2053 m a.s.l.	08^{o}59’33.5’’	037^{o}23’07.7’’	North-facing
			2028 m a.s.l.	08^{o}59’34.7’’	037^{o}23’08.7’’	
			2003 m a.s.l.	08^{o}59’35.5’’	037^{o}23’10.4’’	
			1978 m a.s.l.	08^{o}59’39.3’’	037^{o}23’08.7’’	
			1953 m a.s.l.	08^{o}59’41.2’’	037^{o}23’07.8’’	
			1928 m a.s.l.	08^{o}59’44.9’’	037^{o}23’04.7’’	
			1903 m a.s.l.	08^{o}59’45.8’’	037^{o}23’04.2’’	

		1878 m a.s.l.	08º59’46.6’’	037º23’03.6’’	
		1853 m a.s.l.	08º59’47.4’’	037º23’03.9’’	
		1828 m a.s.l.	08º59’49.1’’	037º23’03.2’’	
		1803 m a.s.l.	08º59’50.8’’	037º22’59.5’’	
2		2053 m a.s.l.	08º59’27.2’’	037º23’10.7’’	East-facing
	4	2028 m a.s.l.	08º59’26.7’’	037º23’12.5’’	
		2003 m a.s.l.	08º59’27.0’’	037º23’14.1’’	
		1978 m a.s.l.	08º59’29.9’’	037º23’15.8’’	
3		2053 m a.s.l.	08º59’29.3’’	037º23’06.7’’	South-facing
	5	2028 m a.s.l.	08º59’24.5’’	037º23’07.9’’	
		2003 m a.s.l.	08º59’20.8’’	037º23’09.6’’	

		1978 m a.s.l.	08º59’18.7’’	037º59’10.3’’	
		1953 m a.s.l.	08º59’16.1’’	037º23’13.9’’	
4	11	2053 m a.s.l.	08º59’34.1’’	037º23’05.0’’	West-facing
		2028 m a.s.l.	08º59’36.4’’	037º23’02.6’’	
		2003 m a.s.l.	08º59’37.9’’	037º23’01.3’’	
		1978 m a.s.l.	08º59’37.5’’	037º22’58.9’’	
		1953 m a.s.l.	08º59’37.6’’	037º22’56.9’’	
		1928 m a.s.l.	08º59’39.6’’	037º22’55.4’’	
		1903 m a.s.l.	08º59’40.0’’	037º22’52.1’’	
		1878 m a.s.l.	08º59’40.3’’	037º22’50.6’’	
		1853 m a.s.l.	08º59’40.0’’	037º22’49.1’’	

			1828 m a.s.l.	08º59’41.0’’	037º22’46.4’’	
			1803 m a.s.l.	08º59’42.0’’	037º22’45.5’’	
Jato	5	6	2000 m a.s.l.	08º59’05.0’’	037º22’05.3’’	North-facing
			1975 m a.s.l.	08º59’06.3’’	037º22’06.4’’	
			1950 m a.s.l.	08º59’08.5’’	037º22’05.3’’	
			1925 m a.s.l.	08º59’08.4’’	037º22’07.6’’	
			1900 m a.s.l.	08º59 09.6’’	037º22’08.6’’	
			1875 m a.s.l.	08º59’10.8’’	037º22’10.0’’	
	6	7	2020 m a.s.l.	08º58’56.0’’	037º21’46.1’’	North-facing
			1995 m a.s.l.	08º58’55.7’’	037º21’43.1’’	
			1970 m a.s.l.	08º58’57.3’	037º21’42.7’’	

			’		
		1945 m a.s.l.	08º58’56.6’’	037º21’40.6’’	
		1920 m a.s.l.	08º58’57.0’’	037º21’38.8’’	
		1895 m a.s.l.	08º58’57.5’’	037º21’36.6’’	
		1870 m a.s.l.	08º59’00.5’’	037º21’34.6’’	
7		2136 m a.s.l.	08º58’42.8’’	037º21’53.7’’	Northwest-facing
		2080 m a.s.l.	08º58’41.5’’	037º21’51.7’’	
	9	2055 m a.s.l.	08º58’41.9’’	037º21’50.0’’	
		2030 m a.s.l.	08º58’42.9’’	037º21’48.8’’	
		2005 m a.s.l.	08º58’43.2’’	037º21’47.2’’	
		1980 m a.s.l.	08º58’42.2’’	037º21’45.4’’	
		1955 m a.s.l.	08º58’42.5’	037º21’43.5’’	

	’	
1930 m a.s.l.	08º58’43.9’ ’	037º21’41.6’’
1905 m a.s.l.	08º58’42.8’ ’	037º21’53.7’’

Appendix Table 2: Proportions of species recorded in each plant families from Dirki-Jato

Family	Number of genera	Number of species	% of species
Fabaceae	11	14	13.21
Euphorbiaceae	6	6	5.66
Rubiaceae	6	6	5.66
Combertaceae	2	6	5.66
Moraceae	1	6	5.66
Oleaceae	3	4	3.77
Celastraceae	1	3	2.83
Verbenaceae	3	3	2.83
Sapindaceae	2	3	2.83
Loganiaceae	2	3	2.83
Lamiaceae	2	3	2.83
Asteraceae	1	3	2.83
Rosaceae	2	2	1.89
Boraginaceae	2	2	1.89
Malvaceae	2	2	1.89
Ranunculaceae	1	2	1.89
Flacourtaceae	2	2	1.89
Myrsinaceae	2	2	1.89

Myrtaceae	2	2	1.89
Anacardiaceae	1	2	1.89
Rutaceae	2	2	1.89
Acanthaceae	1	1	0.94
Rhamnaceae	1	1	0.94
Apocynaceae	1	1	0.94
Ebenaceae	1	1	0.94
Solanaceae	1	1	0.94
Palmae	1	1	0.94
Aquifoliaceae	1	1	0.94
Araliaceae	1	1	0.94
Asclepiadaceae	1	1	0.94
Bignoniaceae	1	1	0.94
Capparidaceae	1	1	0.94
Dracaenaceae	1	1	0.94
Hypericaceae	1	1	0.94
Icacinaceae	1	1	0.94
Meliaceae	1	1	0.94
Melianthaceae	1	1	0.94
Oliniaceae	1	1	0.94
Phytolaccaceae	1	1	0.94
Pittosporaceae	1	1	0.94
Podocarpaceae	1	1	0.94
Salicaceae	1	1	0.94
Santalaceae	1	1	0.94
Sapotaceae	1	1	0.94
Simaroubaceae	1	1	0.94
Sterculiaceae	1	1	0.94
Thymelaeaceae	1	1	0.94
Tiliaceae	1	1	0.94

Ulmaceae	1	1	0.94
Total	84	106	100

Appendix 3: Shannon-wiener Diversity (H'), index and the average evenness values

No	Scientific Name	Seedling	Sapling	Mature	Total	Pi	Lnpi	H'	E
1	*Abutilon longicuspe* Hoehst. exA. Rich.	25	16	16.59	57.59	0.04817	3.033	0.1461	0.037
2	*Acacia abyssinica* Hochst. ex Benth.	2	3.33	41.05	46.38	0.00337	5.684	0.0192	0.006
3	*Acacia etbaica* Schweinf.	1	4	60.51	65.51	0.00017	8.517	0.0015	0.001
4	*Acacia persiciflora* Pax	10	12.35	40.40	62.75	0.00104	6.908	0.0072	0.001
5	*Acanthus sennii* Chiov.	103	60.70	100.09	263.79	0.00502	5.298	0.0266	0.001
6	*Albizia schimperiana* Oliv.	20	19	40.45	79.45	0.0013	6.645	0.0086	0.002
7	*Allophylus macrobotrys* Gilg	15	24.05	40.40	79.45	0.00838	4.78	0.0401	0.005
8	*Allophylus africanus* P. Beauv.	2	2	10.07	14.07	0.00017	8.517	0.0015	0.001
9	*Apodytes dimidiata* E. Mey. ex Am.	14	20.10	23.79	57.89	0.00286	5.843	0.0167	0.022
10	*Bersama abyssinica* Fresen.	30.90	23.03	13.93	66.96	0.00026	8.112	0.0021	0.001
11	*Bridelia micrantha* (Hochst.) Baill.	70.03	20	36	126.03	0.00986	4.615	0.0455	0.0001
12	*Brucea antidysenterica* J.F.Mill.	40	21.06	51.16	112.22	0.01375	4.29	0.059	0.0003
13	*Buddelja davidii* Franch.	5	20	33.03	58.48	0.01496	4.206	0.0629	0.001
14	*Buddleja polystachya* Fresen.	15	10	13	63.26	0.00536	5.22	0.028	0.001
15	*Calpurnia aurea* (Ait.) Benth.	85.20	95	105.30	285.50	0.00061	7.419	0.0045	0.0002
16	*Capparis tomentosa* Lam.	100	155	255	510	0.00104	6.908	0.0072	0.00003
17	*Carissa spinarum* L.	45	55	145.75	245.75	0.0018	6.32	0.0114	0.00001
18	*Celtis africana* Burm.f.	60	91	198	349	0.00026	8.111	0.0021	0.0001
19	*Chionanthus mildbraedii* (Gilg &Schellenb.) Stearn	2.29	2.2	7.3	11.79	0.01124	4.492	0.0505	0.078
20	*Clausena anisata* (Willd). Benth.	34	66	113	213	0.01529	4.206	0.0643	0.0002
21	*Clematis longicauda* Steud.ex A. Rich.	16	23	61	100	0.00329	5.714	0.0188	0.0003
22	*Clematis simensis* Fresen.	9	19	52	80	0.00657	5.021	0.033	0.002
23	*Clerodendrum myricoides*(Hochst.) Vatke	4.41	12	18.31	34.72	0.00112	6.812	0.0077	0.092
24	Clutia abyssinica Jab.&-Spach	37.15	83.59	120	240.74	0.00018	8.517	0.0015	0.000032
25	Combretum adenogonium Steud. ex A.	10.02	10.50	15	45.52	0.00052	5.259	0.0028	0.067

	Rich.								
26	Combretum collinun Fresen	6.2	12.10	28	46.30	0.00173	6.377	0.011	0.038
27	*Combretum molle* R. Br. ex G.Don	10	10.70	15.05	45.75	0.03486	3.355	0.1169	0.039
28	*Combretum nigrican Lepr.ex Guill.&per*	3.16	7.10	16.50	26.76	0.00173	6.377	0.011	0.098
29	*Cordia africana* L.	0	0	5.79	5.79	0.03468	6.119	0.2133	0.10
30	*Crotalaria rosenii(Pax) Milne-Redh.ex polhill*	8.43	9.33	29	46.76	0.00034	8.112	0.0028	0.038
31	*Croton macrostachyus* Del.	3.17	4.10	13.30	20.57	0.00043	7.824	0.0034	0.2
32	*Dalbergia lactea* Vatke	6	15.15	44	65.15	0.00086	7.013	0.0061	0.001
33	*Dodonaea angustifolia* L. f.	17	23	49	89	0.03184	3.448	0.1098	0.0001
34	*Dombeya torrida* (G.F. Gmel.) P. Bamps	25	35	69	129	0.00061	7.419	0.0045	0.0001
35	*Dovyalis abyssinica* (A. Rich.) Warb.	1	1.30	3.02	5.32	0.03126	3.464	0.1083	0.99
36	*Dracaena steudneri* Engl.	6	14	35	55	0.00138	6.571	0.0091	0.002
37	*Ehretia cymosa* Thonn.	8.13	10	10	28.13	0.03126	4.615	0.1443	0.01
38	*Ekebergia capensis* Sparrm.	2	2.05	6.60	10.65	0.00311	5.776	0.018	0.03
39	*Eucalyptus camaldulensisDehnh.*	0	0	66.59	66.59	0.00052	7.6	0.0039	0.001
40	*Euclea divinorum Hiern*	5	5.10	23	33.10	0.0077	4.867	0.0375	0.03
41	*Entada abyssinica* Steud. exA. Rich.	34.60	46	97.01	167.61	0.00268	5.915	0.0159	0.001
42	*Erythrococca abyssinica* Pax	10	10.54	12.44	32.93	0.0241	3.726	0.0898	0.06
43	*Ficus mucuso* Ficalho.	2	4	9	15	0.00268	5.915	0.0159	0.4
44	*Ficus salicifolia* A. Rich.	15	10.41	10.51	35.92	0.00942	4.667	0.044	0.12
46	*Ficus sycomorus* L.	2.25	2	3	8.25	0.01469	4.22	0.062	0.2
47	*Ficus thonningii* Blume	1	1.30	4.04	6.34	0.0186	3.985	0.0741	0.2
48	*Ficus vasta* Forssk.	3	2	3.5	8.5	0.01773	4.034	0.0715	0.04
49	*Flacourtia indica* (Burm.f.) Merr	9	9.15	20	38.15	0.00147	6.502	0.0096	0.03
50	*Galiniera saxifraga* (Hochst.) Bridson	4.13	6.30	14	24.43	0.00078	7.13	0.0056	0.05
51	*Gardenia ternifolia* Schumach. &Thonn.	6	12.62	21	39.62	0.00164	6.438	0.0106	0.02
52	*Gnidia glauca* (Fresen.) Gilg	10	5.27	5	20.27	0.00493	5.319	0.0262	0.03
53	*Grewia ferruginea* Hochst.ex A. Rich.	25.75	35	103	163.75	0.00121	6.725	0.0081	0.0005
54	*Hymenodictyonfloribundum*(Hochst. &	1.11	1.18	3	5.29	0.01254	4.382	0.0549	0.01

	Steud.)								
55	*Hypericum quartinionum A. Rich*	1	1.16	3.40	5.56	0.01097	4.51	0.0495	0.01
56	*Ilex mitis L.Radlk.*	2	3.29	21	26.29	0.00338	5.684	0.0192	0.005
57	*Lantana trifolia L.*	3.30	7.63	18	28.93	0.03286	3.414	0.1122	0.004
58	*Lippia adoensis* Hochst. ex Walp	39.44	51.44	103	193.88	0.00346	5.655	0.0196	0.0002
59	*Maesa lanceolata* Forssk.	40.14	61.20	140	241.34	0.00139	6.571	0.0091	0.0004
60	*Maytenus arbutifolia* (A.Rich.) Wilczek	124	120	110	354	0.00104	6.908	0.0072	0.00002
61	*Maytenus gracilipes* (Welw. ex Oliv.) Exell	69.64	101	206	376.64	0.0013	6.645	0.0086	0.0006
62	*Maytenus obscura* (A. Rich.) Cuf.	26.23	74	137	237.23	0.00838	4.78	0.0401	0.0002
63	*Millettia ferruginea* (Hochst.) Bak.	27.34	23.46	24	74.80	0.00017	8.517	0.0015	0.002
64	*Mimosa pigra* L.	6.34	8.60	22	36.94	0.01038	4.566	0.0474	0.09
65	*Mimusops kummel* A. DC.	10.19	15.60	30	55.79	0.0032	5.745	0.0184	0.001
66	*Myrsine africana* L.	30.25	45.26	72	142.51	0.00284	5.878	0.0167	0.0003
67	*Nuxia congesta* R.Br. ex Fresen.	35	40	75	150	0.00043	7.824	0.0034	0.003
68	*Ocimum lamiifolium* Hochst. ex. Benth.	17	23	67	107	0.97	0.031	0.0301	0.0004
69	*Ocimum urticifolium* Roth.	20	20.73	25	65.73	0.05755	4.625	0.2662	0.0001
70	*Olea capensi*Lsubsp.*macrocarpa* (C.H. Wright)Verdc.	3	5	7	15	0.00536	5.22	0.028	0.01
71	*Olea europaea* L. subsp. *cuspidata* (Wall.ex G.Don)	8	6	5	19	0.00173	6.377	0.011	0.01
72	*Olinia aequipetala(Delile)* Cuf	29	41	100	170	0.00061	7.419	0.0045	
73	*Osyris quadripartita* Decne	50.30	50.30	10	110.60	0.00378	5.573	0.0211	
74	*Periploce llnearlfolia Quart.Dill A.Rich*	16	24	62	102	0.00108	6.811	0.0074	
75	*Phoenix reclinata* Jacq.	50	30	25	105	0.0018	6.32	0.0114	
76	*Pliostigma thonningii(Schumach.) Milne-Redh*	14.05	18.70	38	70.75	0.00077	7.13	0.0055	
77	*Phytolacca dodecandra L'Herit.*	2	3	7	12	0.00095	7.013	0.0067	
78	*Podocarpus falcatus*(Thunb.) R.B. ex. Mirb.	5	5.44	5.43	15.87	0.01124	4.492	0.0505	
79	*Premna schimperi* Engl.	73	103	199	372	0.01529	4.18	0.0639	

80	*Prunus africana*(Hook.f.) Kalkm.	1	2.58	2	4.58	0.00329	5.714	0.0188	
81	*Pterolobium stellantum (Foressk.) Brenan*	40.07	62.90	150	252.97	0.00657	5.021	0.033	
82	*Psychotria orophila Petit*	7	13.06	15.10	35.16	0.00293	5.843	0.0171	
83	*Rhus natalensis* Krauss	90.27	53	100	243.27	0.00112	4.492	0.0051	
84	*Rhus vulgaris* Meikle	43	58	138	239	0.00068	7.264	0.005	
85	*Ricinus communis* L.	11	11.25	11.34	33.59	0.01228	4.398	0.054	
86	*Rosa abyssinica* Lindley	100	107	90	297	0.05612	2.88	0.1616	
87	*Rothmannia urcelliformis* (Hiem) Robyns	12	13	32	55	0.00173	6.377	0.011	
88	*Rytigynia neglecta* (Hiera) Robuns	27.62	73	109	209.62	0.00856	4.756	0.0407	
89	*Salix mucronata* Thunb. (S. subserrata Willd)	30	27	20.47	77.47	0.00173	6.377	0.011	
90	*Sapium ellipticum* (Krauss) Pax.	7	13	39	59	0.00225	6.12	0.0138	
91	*Schefflera abyssinica*(Hochst. ex A. Rich.) Harms	0	0	20.17	20.17	0.00036	7.824	0.0028	
92	*Schrebera alata* (Hochst.) Welw.	8.20	12.11	37	57.31	0.00034	8.112	0.0028	
93	*Scutia myrtina* (Burm. f.) Kurz	7.41	9.24	17	33.65	0.00052	7.6	0.0039	
94	*Senna petersiana* (Bolle) Lock	10	18	20.63	48.63	0.00622	5.083	0.0316	
95	*Senn obtusifolia L.*	10.33	17	33.33	60.66	0.05791	2.849	0.165	
96	*Sida rhombifolia L.*	29.52	37.42	40	106.94	0.00069	7.264	0.005	
97	*Solanum marginatum L.f.*	11.05	16.90	29	56.95	0.00139	6.57	0.0091	
98	*Stereospermum kunthianum* Cham.	11.11	17	30	58.11	0.00727	4.92	0.0358	
99	*Syzygium guineense* (Willd.) DC.	19	31	70	120	0.00986	4.615	0.0455	
100	*Teclea nobilis* Del.	21	13.30	7.15	41.45	0.01799	4.017	0.0723	
101	*Terminalia macroptera* Guill & Perr.	35	27	28	85	0.00311	5.776	0.018	
102	*Terminalia schimperiana* Hochst.	18	7.14	5.60	30.74	0.01978	3.922	0.0776	
103	*Vangueria apiculata* K. Schum.	37	20.38	20	77.38	0.00052	7.6	0.004	
105	*Vernonia leopoldi (Sch.Bip.ex Walp.) Vatke*	29.30	21.66	23	73.96	0.00268	5.915	0.0159	
106	*Vernonia myriantha Hook.f.*	100	48	20.54	168.54	0.01176	4.44	0.0522	

	Total	**2437.8 0**	**2801. 77**	**4962.8**	**10202. 37**	**1.84744 3**	**608.265**	**3.23**	

Appendix Figure 1: Dirki site

Appendix Figure 2: Jato site